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ABSTRACT

This paper is a discussion of the different contexts in which the concept of the infant's state is used in infant research. The infant states discussed are: regular sleep, irregular sleep, drowsiness, alert inactivity, waking activity, and crying. Also included are hunger periods and indeterminate states, those instances in which an infant's state does not clearly meet the criteria of any of the other states. A brief summary of neonatal studies which explore both innate and experiential factors affecting behavior and development of newborns is given. Without controlling for state, infant studies may yield both false positive and false negative results. State can be considered a variable, the primary focus of research rather than an intervening factor. Research in the area of state proposed included those dealing with distinctness, predictability, range, and flexibility of state. State may also be a mediator of stimulation. In studies assessing the effects of early stimulation, it is important to determine which types of stimulation are most effective at various developmental stages and the optimal state of the infant during which such stimulation can take effect. Bibliography and tables included. (Author/AJ)

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STATE AS VARIABLE, AS OBSTACLE AND AS MEDIATOR OF STIMULATION IN INFANT RESEARCH[1]

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In recent years, one of the most frequently discussed topics in the field of infant research is the issue of the infant's state as it affects his behavior and his responses. Most often, the infant's state is viewed as an obstacle, an interference or a downright nuisance which, unless controlled for, stands in the way of making reliable observations and of understanding the infant's responses. Less frequently, state is discussed as a variable in its own right or as a necessary pre-condition for stimulation to be effective. In this paper, I will attempt to discuss separately the different contexts in which the concept of state is used, at the risk perhaps, of artificially separating issues which overlap to some extent. In discussing and illustrating the contextual differences in which state is used, I shall draw, as I was asked to do, mostly on examples from my own research with newborns. On occasion, I shall also provide illustrations from the research of other investigators.

When in our work with newborns we speak of the infants' states, we refer to Peter Wolff's (1966) classification of states. We use his behavioral criteria for determining state with only very minor modifications. Wolff's state definitions correspond very closely to those described by Prechtl (1964) and his group of developmental neurologists in Groningen. Prechtl, in his highly sophisticated work with neonates, probably was the first to stress the overriding and critical importance of considering state in evaluating <u>any</u> response on the part of the newborn.

Other investigators have devised slightly different classifications of the infants' states. Among these are Brazelton's (1970), Janet Brown's (1964), Weller and Bell's (1965) and most recently, Boismier's (1970) and his collaborators' classifications. When one compares these different schemes, it is striking that the overlap of criteria far exceeds the differences. This suggests that, even though we are dealing with only a concept called state as opposed to a concrete entity, there is substantive agreement regarding the criteria of state which are useful in understanding an infant's behavior at any given point in time.

Let me briefly outline what states of the infant we will be talking about. I shall do this in bold strokes and describe only the principal criteria by which we identify the infant's state. For a more complete and detailed description of the criteria used, I refer you to Wolff's monograph (1966) on the "Causes, Controls and Organization of Behavior in the Newborn". We classify an infant as being in regular sleep when his eyes are closed and he is completely still for the most part. His respirations are slow and regular; his face is relaxed, he does not grimace and his eyelids are still. The infant is considered to be in irregular sleep when his eyes are closed and when he engages in variable gentle limb movements, writhing and stirring. Grimaces and other facial expressions are frequent; respirations are irregular and faster than in regular sleep. Within this state, interspersed and recurrent rapid eye movements can be seen through the eyelids. These are a part of what the sleep researchers call the phasic events of paradoxical sleep or otherwise known as REM's. The infant is classified as being in the state of drowsiness, when he is relatively inactive, when his eyes open and close intermittently and when his respirations are fairly regular, though faster than in regular sleep. When his eyes are open, they have a dull or glazed appearance. This is in contrast to the appearance of his eyes during alert inactivity. In that state, his eyes are open and have a bright and shining appearance. The infant is capable in this state to pursue moving objects and to make conjugate eye movements

both in the horizontal and the vertical plane. The infant is relatively inactive in this state; his face is relaxed and he does not grimace. In waking activity, the infant frequently engages in diffuse motor activity involving his whole body. His eyes are open but not alert. Respirations are grossly irregular. The state of crying is characterized by crying vocalizations associated with vigorous, diffuse motor activity.

These states have often erroneously been called states of arousal. Undoubtedly, this came to pass because superficially they appear to express the range from the infant's lowest to the highest degree of activation. As Wolff has frequently pointed out, these states do not represent a continuum of arousal of the infant, but are qualitatively different conditions, with a distinct type of internal organization. This is very clearly born out by EEG criteria of various states which show that the brain is at least as activated or "aroused" during irregular REM sleep as during waking.

You may wonder, why we don't use EEG criteria altogether to determine state. In some types of infant research this is absolutely essential, particularly in certain sleep studies and in investigations primarily concerned with brain maturation. Not being a psychophysiologist, I personally don't "hook up" babies, as it is called in the trade. It is reassuring and of interest that the behavioral state criteria correlate quite well with the EEG criteria. Conceivably, the behavioral criteria may even be more accurate than the EEG criteria in describing the state of the infant, because the behavioral criteria were devised with the infant in mind, whereas the EEG criteria had to be converted and adapted from adult standards.

In my work with newborns I have added a state to those of Wolff's, a state which I have loosely called an indeterminate state. This classification is used in those instances in which the infant's state does not clearly meet the criteria of any of the other states. This category was added not only to avoid misclassifications but also as a behavioral variable in its own right. As I will try to

show later, the fact that some infants convey and perhaps experience their internal states less clearly than others may be an important attribute in their make-up which may become a source of confusion to their caretaker and may delay the development of internal sets of expectations.

In my discussion of the impact of state on neonatal behavior, I shall also refer to the influence of hunger. While hunger is an entirely different phenomenon from the states already described, one may nevertheless think of hunger as a state in terms of its periodic, universal and biological nature. Since there is no reliable index of the intensity with which a given infant experiences hunger, hunger is of necessity an inferential state. We thus inferred hunger from the length of time elapsed since the last feeding, assuming that hunger would increase as a function of time.

Before I will proceed to illustrate from my neonatal studies in what way state can be an obstacle, a variable, or a mediator of stimulation, it might help to give you first a very general description of these studies.

Description of Neonatal Studies

Our neonatal studies are designed to explore both innate and experiential factors as these affect the behavior and development of newborns. We have long been involved in studies of individual differences among neonates and have tried to assess these differences before at least extra-uterine experience could much affect the infants in a differential way. Our interest in assessing individual differences has been governed by three very general considerations: We feel that individual differences assessed shortly after birth may contain rudiments of the individual's later characteristics and may differentially affect the unfolding of many of his later functions. We also strongly suspect that such differences may influence the manner in which universal childhood events are experienced and perceived by any given child. Furthermore, we feel that such variations should, in the interest of mother-infant mutuality, evoke differences in mothering.

In our early experience studies we have sought to identify the maturationally most adequate forms of stimulation which are relevant for the first weeks of life. We have attempted to pinpoint these in the context of the types of stimulation ordinarily provided by maternal care. For both types of studies, we have included in our samples only full-term, healthy newborns. This was particularly important in the individual differences studies since otherwise we might have found differences among babies purely as a function of pre- and postnatal complications. Thus we applied stringent selection criteria with respect to maternal labor, medication and delivery, parental metabolic and neurological status, the infant's condition at birth, his weight range and his physical status during the entire lying-in period. This was done to make certain that only the healthiest babies were included for study.

We developed standard procedures of observation for each of our studies. In this way we observedthe infants under identical external conditions which insured that whatever individual differences we found were not a function of differing conditions of observation. We always observe the infants at a comparable time of day. Illumination and temperature are kept constant. Since the position of the infant frequently affects his responses, we control for this factor in each observation. In our experimental studies, the sensory stimuli provided are standard in duration and intensity.

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In one of our studies, we used film to record the infant's behavior. In fact, we have taken 1000 feet of film on each of 32 babies and we have thus accumulated a bank of behavioral data on the neonate which can be used by us and other investigators for a host of investigative purposes. Sixteen time samples were taken on each infant, interspersed among two prefeed half hours, one postfeed half hour and during the half hour at midpoint between feedings. A timer attached to the camera automatically turned the camera on and off, thus taking behavior samples which were identical for each infant in the length and in the interval since

the last feeding.

With the help of a computer attachment built for our projector which allows us to analyze film at a predetermined number of frame units at a time, we have to date undertaken five separate film analyses. These have revolved largely around individual differences in various spontaneous oral behaviors, the frequency and the types of the infants' motions, and the relation between the infants' oral and motility characteristics (Korner, Chuck and Dontchos, 1968; Korner and Kraemer, 1970). Most recently, we have concentrated on exploring the temporal relation between two of the most highly organized neonatal behaviors, namely hand to mouth coordination and visual behavior.

Observer reliabilities, incedentally have been high throughout, both in the direct observations of the infants and in the film analyses. At the beginning of each study and periodically throughout we check inter-observer agreements. Agreements have been way above 90% in all but two behavior categories. In the film analyses, in order to avoid subtle changes in scoring criteria over time, we not only establish inter-observer agreement levels, but also score-rescore reliabilities for the same person throughout the period film is analysed.

Now that I have described in a general way what kinds of studies we have undertaken, let me turn to the discussion of the relevancy of state in these studies. I shall begin by illustrating in what way state can be an obstacle in infant research.

State as Obstacle in Infant Research

Escalona (1962), in a classical paper entitled "The study of individual differences and the problem of state" called the state variable a source of "bedevilment" to investigators who attempt to study the behavior of young infants. This is particularly true in studies of individual differences, as I will try to illustrate from our studies. It is, however, also true of studies which attempt to investigate what infants have in common at any given developmental

stage, or how they respond to differences in experimental treatments. Interestingly enough, if one does not control for state, one is apt to obtain both false positive and false negative results. False positive results are most likely to occur in individual difference studies. Let me illustrate from the influence state exerts on the infant's responsiveness to sensory stimulation. In one of our studies we used a buzzer emitting unpure tone of approximately 80 decibels for 2/5 of a second at a distance of about 2 feet from the infant's exposed ear. In a preliminary unpublished study, I found, as other investigators have (i.e. Wolff, 1959; Eisenberg, Griffin, Coursin and Hunter, 1964) that thresholds to auditory stimulation vary with the state the infant happens to be in, and that they tend to be higher in regular sleep and during crying, than during irregular sleep, drowsiness or alert inactivity. I also noted, as Wolff (1959) already had, that not only did the frequency of response as gauged by indices of behavioral change vary with the infant's state, but also the kind of response the infant would give in response to auditory stimulation. Thus, if he did respond at all during regular sleep, he was apt to react with a vigorous startle, while the same stimulus would only evoke a palpepral blink or a minor body movement during irregular sleep. From this, it was quite clear that if we wished to compare infants with respect to their relative responsiveness to auditory stimulation, they all had to be tested in the same state, and as I will show later, during a comparable time interval since the last feeding. In the case of auditory stimulation, we chose to test all infants while they were in irregular sleep and this choice was based on the rationale that irregular sleep is very prevalent among newborns and that auditory thresholds in this state are relatively low. With other types of sensory stimulation experiments we, of necessity, also had to choose a pre-determined, pre-stimulus state, for only in so doing, were we able to compare infants among each other with respect to their relative sensory sensitivity. Clearly, unless one controls for state, one is apt to find false individual differences, differences

which are purely a function of the infant's state rather than his individuality.

False negative results are also easy to come by if one does not control for state. These plague more frequently the types of studies which investigate the effect of an experimental treatment as well as studies which explore what certain populations of infants have in common. If, for example, in a conditioning study one does not strictly control for the infant's state at the time of testing, the infant's response may be so variable that one may conclude wrongly that the conditioning had little or no effect (See a discussion of this problem by Connolly and Stratton, 1969). Or, if one wants to identify neurologically suspect newborns as Lenard and other associates of Prechtl's (1968) have done with admirable prognostication, it is absolutely imperative that one test each of the reflexes while the infants are in a comparable state. Otherwise, one may judge as abnormal the absence of reflex responses, a failure which may be purely a function of the infant's momentary state.

State does not necessarily have to represent a source of error or confusion. If routinely taken into account, it is an aid in systematic observations, a reference point regarding the infant's behavior at any given moment, and an organizer of otherwise confusing data. Any naive observer can testify how utterly confusing it is to watch a newborn and to bring any sense or order to his observations. This sense of bewilderment vanishes when the infant's behaviors are brought into the context of his states. For example, infants startle, grimace and smile, they suck, they tongue and engage in rhythmical mouthing. Boy babies have erections. Some of these spontaneous behaviors are not at all random, but they occur in each baby only in certain states. Also, their frequency varies with each state. For example, reflex smiles in the newborn never occur in regular sleep. They are most common in irregular sleep with and without REM's. They occasionally occur during drowsiness. On the rarest occasions, and usually only in response to a sudden visual and auditory stimulus and right after a feeding, do smiles occur during alert

inactivity. Vigorous startles are by far the most frequent during regular sleep; they are less common and less vigorous during irregular sleep and drowsiness and are extremely rare in the waking states. Erections occur primarily during irregular sleep, particularly during the rapid eye movement phase. To a lesser extent, they also occur in regular sleep and during drowsiness. Rhythmical mouthing is primarily associated with regular sleep.

These and other findings were derived from systematic observations of these phenomena, first by Wolff (1966) and later confirmed in one of our studies (Korner, 1969). Through lengthy monitoring of states, we quantified the hourly rate of each of these spontaneous behaviors in each state. Interesting sex and individual differences emerged in our study from these observations. The results on sex differences reflected a highly consistent trend for males to startle more in all states and for females to engage more frequently in reflex smiles and bursts of rhythmical mouthing. Since the mean rate of the spontaneous behaviors was almost identical for males and females when erections were excluded, it seemed that females made up in smiles and reflex sucks what they lacked in startles. It also appeared from our results that individual infants heavily relied on specific discharge channels over states. Thus, infants who startled a lot in regular sleep also tended to be the ones who startled frequently in irregular sleep. The rank correlation was .49, significant at $p < .01$. This relation was more marked in the case of erections. The rank correlation between the rate of erections in regular sleep and irregular sleep was .77, significant at $p < .001$.

Applying these findings to the issue of state being either a confusing or an organizing factor, it is clear that one may draw the wrong conclusions about the individual characteristics of a given baby either from the frequent occurrence or the total absence of these spontaneous behaviors, if one does not consider the state of the infant. It is equally clear, that if one is not interested in individual differences, but wants to investigate in a phenomenological way, the nature

and the prevalence of these spontaneous behaviors among babies, consideration of the state in which these behaviors occur, is a most powerful ally in organizing otherwise highly confusing observations.

So far, I have talked only about the influence of the sleeping and waking states on the infant's behavior. I want to illustrate next how hunger, as inferred by the time elapsed since the last feeding, may influence an infant's behavioral response. We systematically gathered much of our data in the half hours immediately following and preceding a feeding and at midpoint between feeds. Analyses of variance showed highly significant differences between periods in a great number of behaviors. For example, the infants' response to auditory stimulation differed significantly between periods, with the infants being most responsive right after a feeding, and least responsive midway between feedings. The frequency of mouthing and of the rooting response increased significantly as feeding time approached. Total movement, and particularly diffuse motions increased significantly with hunger, and single motions decreased accordingly. In the state dimensions, sleeping states, particularly regular sleep significantly decreased with hunger, whereas crying frequency and the number of shifts of states increased. None of these findings are particularly surprising or contrary to expectations. They do however, convey a point that must be considered by anyone doing infant research and that is, that infants behave differently depending on when during the hunger cycle they are observed. Without controlling for the time elapsed since the last feeding, one may once more obscure group effects which actually may exist, or find individual differences which are an artifact.

State as a Variable

State, as I hope to show, can be considered as a variable in its own right, as the main focus of research rather than as an intervening factor which either clarifies or obscures the meaningfulness of observations of other types of behavior. State as variable has been one of the most and one of the least researched areas of investigation. Let me begin with some of the least explored areas which pose sub-

tle and difficult problems for investigation but which, in my opinion, also hold great promise in shedding light on both normal and pathological development.

One variable in this realm is the distinctness of the infant's state. Infants vary a great deal in the clarity with which they convey their state. As mentioned before, we attempted to assess this phenomenon by adding a category called "indeterminate state" to Wolff's (1966) state categories, which we used whenever the criteria for classifying an infant's state were fuzzy or blurred. We did not get very far in pursuing this problem because it was a side issue amidst many others at the time, and therefore was not assessed as thoroughly as it would have been had it been the main focus of investigation. Nevertheless, I feel that it would be a very important area to explore, for indistinctness of the manifestation of the infant's states, including those of hunger, undoubtedly represents an individual's first failure to communicate. Indistinctness of state, great variability and unpredictability of states must have a profound effect on the beginning mother-infant relationship. When mothers talk about easy or difficult babies to take care of, they undoubtedly refer in great part to the ease with which they can "read" their infant's needs at any given moment. Equally important, particularly for the infant's later development, may be the distinctness with which he experiences the internal stimuli generated by hi states, especially those of hunger. Conceivably, such indistinctness may delay the development of internal sets of expectations and of the anticipatory functions. Blurredness of the experience of internal states may also delay the distinctions between internal and external reality and may predispose to later regression in this distinction.

Of interest in this connection are reports from psychopathology. For example, adult schizophrenics show on EEG an unusually large percentage of "intermediary" sleep stages which are so classified on the basis that they simultaneously show characteristics of several sleep stages (Koresko, Snyder and Feinberg, 1963; Vincent, Favarel-Garrigues, Bourgeois and Dufet, 1968). Also of interest are reports both on obese patients and on patients

with anorexia nervosa to the effect that these patients have not learned to know when they are hungry (Griggs and Stunkard, 1964; Bruch, 1966). Particularly interesting in this connection is Dowling's report (1970) on the development of infants who were never allowed to experience hunger. He described three children born with esophageal atresia, a correctable, congenital anomaly which prevents passage of food from mouth to stomach. Surgical repair of these particular children was not possible until they were two years old. Until then, they received nourishment through a gastric fistula which was made surgically through an opening leading to the stomach. Food was given two of these children without oral participation on a 3 hourly schedule, day and night, asleep or awake, without relation to hunger. In each of the children, an opening was also made from the upper segment of the esophagus to the side of the neck. In this way, anything the infant swallowed passed through this opening to the outside. The two children who experienced no oral feedings simultaneously with the gastric feedings, soon developed gross developmental deficits. When one of these children was first seen at 4 weeks of age, both his rooting and sucking reflexes were very weak. Neither of these two children used the mouth, as normally developing infants do, for purposes of exploring, feeling or grasping. Most remarkable was the fact that both these children had a marked lag in gross motor development during the first 2 years of life, even though, on testing both had normal and above normal intelligence at the age of 5 and 6 years. The development of the third infant who was allowed to experience hunger and, who when fed gastrically, also was given solids, was radically different. She was very much interested in food, cried hungrily when waiting for it, becoming active and eager during its preparation. At 22 months of age this child was vigorous, exploratory, and active, and before all, she did not show any of the gross motor lag seen in the two other infants. In discussing the difference in development between these three children, Dowling (1970) invoked the organizing and activation force of hunger as <u>one</u> important factor underlying the lack of gross motor deficit seen in the more

normally developing child.

One may profitably study not only the distinctness and predictability of states, but also the range and flexibility of the states which an infant is capable of. Brazelton (1962) observed several children, who, during the first postnatal weeks, showed a very narrow range of states. These children came under intensive and unsuccessful psychiatric care at a very early age and were later diagnosed as children with "atypical development". Brazelton gave a detailed description of one of these children who essentially was capable of only two states: in the first state the infant appeared to be in deep sleep during which his muscle tone was poor, he was difficult to rouse and impervious to any stimulation. In the second state, he continuously screamed, was hyperactive and hypersensitive to any stimulation. Nothing could calm him except restraint and swaddling which made him revert immediately back to the first state of inaccessible, deep sleep. Repeated neurological examinations revealed no deficit. His development progressed very unevenly, particularly in the motor sphere. The narrow range of this child's states persisted at least until pre-school age when his coping mechanisms were limited to either screaming or withdrawing into a state in which he seemed to neither hear nor see. Aside from the internal difficulties which these state peculiarities engendered, they also had a profound effect on the mother-infant relationship. The mother of this infant was completely overwhelmed by her inability to comfort or reach this child and by his unresponsiveness to her ministrations.

In addition to distinctness, consistency and range of states, alterability of state through stimulation would be a very important variable to study systematically. For example, in comparable states, some infants are extremely difficult to rouse, others respond with minimal stimulation. Similarly, some crying, agitated infants are easily calmed by certain interventions, whereas others react minimally or only very slowly to the very same methods of soothing (Bridger and Birns, 1963; Korner and Thoman, in preparation). The study of the alterability of state may have much

larger applicability than either distinctness or range of states in that it may be an important dimension in normal development, and exert a significant effect on later characterological traits. For example, infants who maintain their reluctance to being roused may become phlegmatic, slow to respond, placid individuals; by contrast, infants who respond to any kind of handling or stimulation with rapid changes in state may become individuals who are highly responsive to any kind of stimulation, to the point, perhaps, of becoming easily overstimulated.

Probably the best researched area in which state is treated as a variable is that of sleep. The last ten years have seen a veritable avalanche of sleep research, and this field has become, without a doubt, one of the most exciting new frontiers in psychological investigation. A number of investigators have systematically explored the sleep characteristics of newborn infants (i.e. Roffwarg, Muzio and Dement, 1966; Ellingson, 1967; Monod, Eliet-Flescher and Dreyfus Brisac, 1967; Parmelee, Wenner, Akiyama, Schultz and Stern, 1967; Prechtl, Akiyama, Zinkin and Grant, 1968; Emde and Metcalf, 1970). One of the recurrent questions posed by this research revolves around the function which the prevalence of the REM state might have in the developing organism. It is an established fact that, within limits, the younger the organism, animal or human, the more prevalent the REM state (Parmelee et al, 1967, Jouvet-Mounier, 1968). Roffwarg et al (1966) advanced the highly plausable hypothesis that the great prominence of the REM state during early life may serve to assist the process of central nervous system maturation and differentiation through the endogenous afferent stimulation which the REM state provides. Within the framework of my study on individual differences, I examined the behavioral manifestations of the REM state, comparing in <u>developmental terms</u>, the organization of the infant's REM state with that of the adult (Korner, 1968). It was of interest that, with one notable exception, the comparison between infant and adult REM associated behaviors highlighted the well known developmental principle which characterizes development as proceeding from the general, or undifferentiated to the increasingly specific

and differentiated (Hamburger, 1947; Werner, 1947). Thus for example, in the normal adult, REM onset is always preceded by 50-90 minutes of nonREM sleep. This contrasts with REM onset in neonates who, in an indiscriminate, undifferentiated way enter REM sleep from almost any state, waking or sleeping. This had already been shown by Roffwarg and his collaborators (1966). In our sample, only 25% of the REM episodes were preceded by regular sleep. The remaining REM periods were preceded by drowsiness, crying and waking activity, in that order of frequency. Similarly, erections which in normal adults occur almost exclusively and synchronously with REM periods (Fisher, Gross and Zuch, 1965), were neither as REM-specific nor as synchronous in newborns. While erections in neonates do primarily occur during REM, which is an interesting precursor to the later obligatory association, they also occur with considerable frequency during regular sleep and to a lesser extent while the infant is drowsy. In each comparison, the REM characteristics of neonates were more generalized and less specific as to function and temporal relations than the adults'. The one exception was in the area of responsiveness to auditory stimulation during REM's and during other states. We found responsiveness to be significantly less frequent during REM's than during any other state except during "deep" or regular sleep. This suggests that during the REM phase, the infant is as impervious to external stimulation as he is during regular sleep, a finding which is apparently also true for adults (Williams, Hammack, Daly, Dement and Lubin, 1964). What is fascinating also is that when one examines the literature on adult sleep pathology, one finds under the impact of extreme stress, a reversion or regression to earlier levels of REM organization in some of the characteristics described. However, this is another long and complicated story, too far removed from our main concerns.

Returning to our topic of state being used as a variable, still other illustrations can be found in investigations focusing on the infant's crying or his capacity for alert inactivity. In certain respects, some of these studies could also be

classified under the heading of state being a mediator, as well as an evoker of stimulation. For example, in our individual differences study (Korner and Grobstein, 1967), we monitored the frequency and duration of crying during 2 hours and 20 minutes on each of 32 subjects. We found significant differences among babies in how much they cried, and when they cried most during the four hour feeding schedule which is prevalent in most hospitals. There were some infants who cried most three hours after the beginning of the last feeding and others who cried most just before the next scheduled feeding. This clearly suggests that some infants would do better on a three hour schedule, particularly since these infants often exhaust themselves crying and fall asleep just before they are scheduled to feed. The individual differences in the amount of crying between babies also imply the need for different care. A very irritable infant not only must affect the mother and her feelings as a caretaker, but will also evoke all sorts of efforts on her part. Since the infant's crying usually elicits maternal ministrations, differences in crying will affect the frequency with which the infant initiates interactions with his mother. In that sense, the state of crying may be considered a mediator or evoker of stimulation.

Crying has also been taken as a variable in diagnostic studies (Fisichelli, Haber, Davis and Karelitz, 1966; Prechtl, Theorell, Gramsbergen and Lind, 1969). There appear to be marked qualitative differences between the cry of the brain injured and the normal infant. In a similar vein, Brazelton and his collaborators (1966) have taken the infant's capacity for the state of alert inactivity and for visual following as a favorable prognostic sign for the neurological intactness of the infant.

The state of alert inactivity has long captured our interest, in that the visual exploratory behavior which often attends this state may be one of the main avenues at the neonate's disposal for getting acquainted with his environment and for early learning. In this sense, the state of alert inactivity is both a varia-

ble and a mediator of stimulation. In our studies, we have been interested both in the general make-up of those infants who are capable of a great deal of visual alertness and in identifying the types of interventions within the context of ordinary maternal care, which will evoke visual alertness in newborns most effectively. In an attempt to find out what the characteristics are of those babies who are capable of a great deal of visual alertness, we monitored the frequency and duration of alert inactivity and correlated these with our other findings on these babies. Among the correlates, one of the most interesting was the strong relation between the state of alert inactivity and the capacity for visual pursuit. The correlations between visual pursuit and duration and frequency of alert inactivity were .60 and .74 respectively ($p < .001$, Korner, 1970). Thus, the babies who spontaneously spent a great deal of time in alert inactivity, also tended to be the most capable of fixating on specific visual stimuli. Both measures thus express a capacity which may be vital for the earliest forms of learning.

State as Mediator of Stimulation

Having already given two examples in which state could be considered not only as a variable, but also as a mediator of stimulation, I shall limit myself to one illustration which, hopefully, will further clarify in what way state can be a mediator of stimulation. Dr. Evelyn Thoman and I recently completed a study in which we attempted to pinpoint what types of stimulation mothers ordinarily provide in the course of caring for their infants (Korner and Thoman, 1970). In particular, we assessed the relative efficacy of body contact and of vestibular stimulation (the stimulation involved in being moved), in evoking visual alertness in newborns. To make my point as to state being a mediator of stimulation, I will need to summarize this study briefly. The subjects were 40 crying and 24 sleeping 2-3 day old newborns, equally divided as to males and females, breast-fed and bottle-fed infants. Each subject was given, in random order, six interventions which entailed singly, or in combination, contact and vestibular stimulation with or without the upright

position. The highest level of alerting achieved during 30 seconds pre- and post intervention was judged by two observers on a 6 point scale. In order to avoid state becoming an obstacle to reliable observations, we controlled for pre-stimulus state. Crying infants were tested only after they fussed for at least one minute and cried vigorously for 10 seconds. Sleeping infants were tested only during irregular sleep without REM's. To avoid experiment-induced heightened arousal, at least two minutes had to elapse between interventions or any handling of the infant. Nothing was done before or during the interventions to induce sleeping or crying in the infant, an inconvenient, though necessary precaution, rarely taken in experimental work with infants. This was done, partly to avoid differential changes in state in response to such manipulations, partly to keep constant the amount of stimulation given each child.

The interventions were:

1. The infant was lifted from the examining table and put to the shoulder, head supported.
2. The infant was lifted horizontally and cradled in arms in the nursing position.
3. Bending over the supine infant, the assistant held the infant close, simulating another nursing position. Care was taken not to move the infant in any way.
4. The infant who had previously been placed in an infant seat, was raised to the upright position.
5. The infant in the infant seat was moved horizontally, as if in a perambulator.
6. The infant was talked to in a high pitched voice, simulating "mother talk". The voice was used as a marker to avoid bias in picking a time during which to observe alerting in the absence of any intervention. This was decided after a preliminary study showed that the voice elic-

ited no more alerting than occurred spontaneously without any intervention.

Table 1 shows the types of stimulation given in each intervention.

Insert Table 1 about here

Figure 1 shows in descending order the level of alertness evoked by each intervention, both in crying and in sleeping infants.

Insert Figure 1 about here

As can be seen from Figure 1, by far the highest level of alerting was evoked by putting the infant to the shoulder. This position evoked bright-eyed scanning in 77.5% of the infants. The photograph in slide 3 portrays a typical reaction on the part of a newborn on being soothed on the shoulder.

Insert photograph of infant here

Returning to Figure 1, we assessed the significance of the difference of response to the six interventions through t tests. This was possible only for the crying infants in as much as the minimal response of the sleeping babies made such testing inappropriate. I shall confine myself here only to our main findings which indicated that vestibular stimulation had a far more powerful effect in evoking visual alertness than did contact, and that contact alone had no greater effect than hearing a highpitched voice, which in turn, judging from preliminary work, had no greater effect on alerting than would occur by chance. The results also clearly showed, that even though sleeping infants responded only minimally, the only two interventions which elicited any visual activity were interventions entailing

vestibular stimulation and the upright position.

We drew several conclusions from this study. One of these was that mothers, in soothing their crying infants by picking them up, will inadvertently provide them with a great many visual experiences (See also Korner and Grobstein, 1966). Another was that if the earliest forms of learning occur mostly through visual exploration, that vestibular stimulation which evokes a good deal of visual alertness in the neonate, may be the more important form of stimulation during this stage of development than the more publicized body contact. What is interesting is that it is a hidden form of stimulation, easily overlooked, because it almost invariably attends experiences involving body contact and tactile stimulation. We also concluded from reading some of the embryological literature, that it makes good sense for the vestibular system to be an excellent mediator for early stimulation. It appears that this system is one of the earliest to develop, begins to function and to be myelinated at 4 months gestational age and is fully mature at birth (Humphrey, 1965; Langworthy, 1933).

Returning to our topic, how does this study illustrate that state can be a mediator of stimulation? Not only does the crying state evoke maternal stimulation, and the state of visual alertness provide environmental stimulation, but <u>depending on the infant's state at the time of intervention</u>, the same type of stimulation will either have a strong or a minimal effect. This was clearly shown by the differential response of sleeping and of crying infants. The whole study suggests that in infant research involving early stimulation, it is important to pin down not only <u>which types of stimulation</u> are most effective at <u>which stages of neurophysiological development</u>, but also to spell out the <u>optimal state of the organism</u> which will facilitate the effectiveness of stimulation.

Summary

In this paper, the influence of several sleeping and waking states and of hunger on the neonate's behavior are described. State is an obstacle and confounds observations in infant research if it is ignored. Without controlling for state, infant studies will yield both false positive and false negative results. Differences among infants will be found which are purely a function of their momentary states rather than their individuality. Likewise, findings over babies, or general effects of interventions will be obscured unless the infants are observed in comparable states. If, on the other hand, one routinely controls for the infant's state, it ceases to be a source of error in making systematic observations. Instead, state becomes a valuable organizer of otherwise confusing data.

State as a variable in its own right was illustrated from examples from sleep research. Also discussed were distinctness of state, range, predictability and alterability of states as these may affect the mother-infant relationship as well as normal and pathological development. The states of crying and of alert inactivity were discussed both under the heading of state as variable and as mediator of stimulation. The paper concludes with a discussion of the results of a study which illustrates that in studies assessing the effects of early stimulation, it is important to pin down not only which types of stimulation are most effective at which stages of development, but also to spell out the optimal state of the infant during which such stimulation can take an effect.

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TABLE 1

TYPES OF STIMULATION PROVIDED

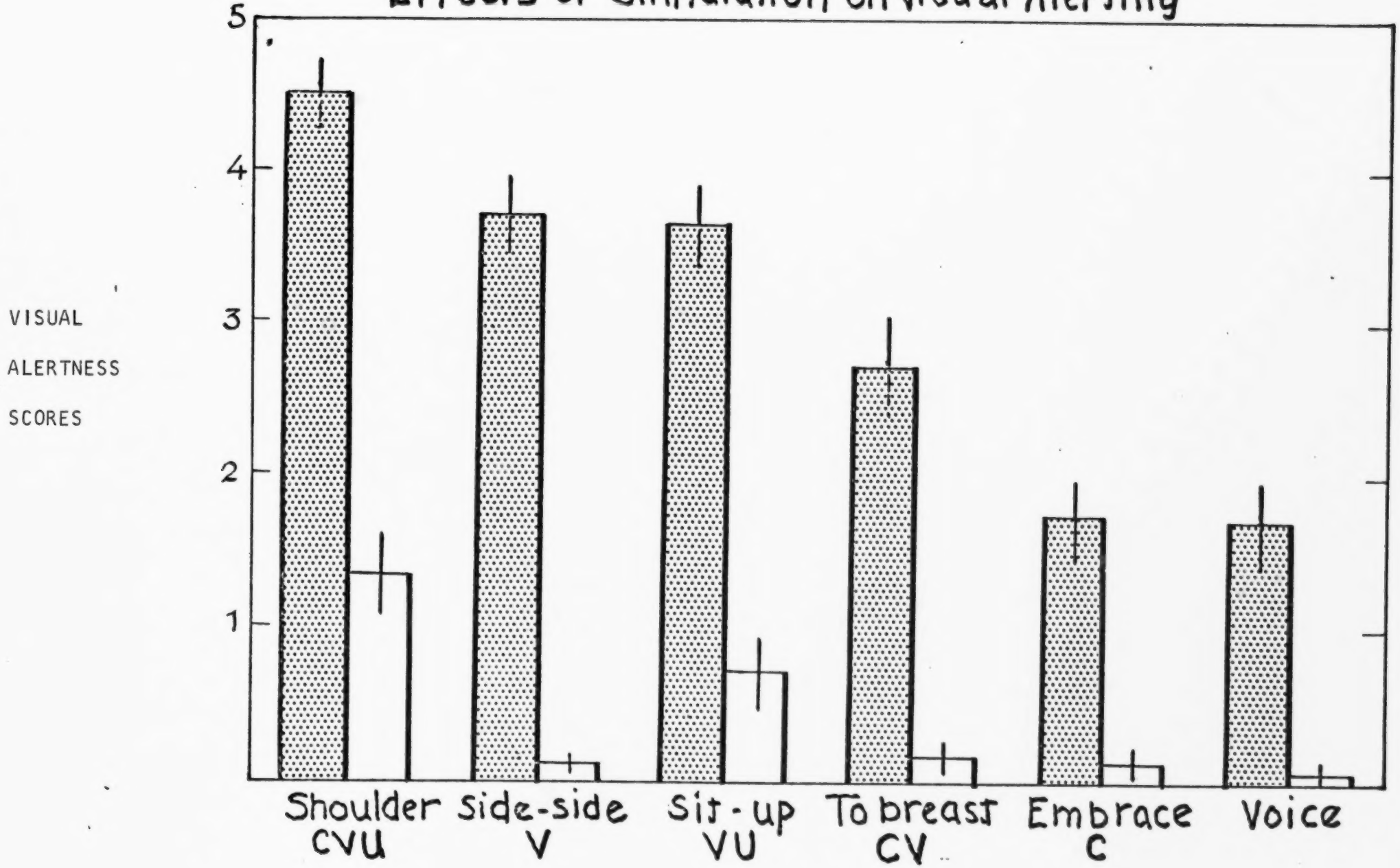
BY EACH INTERVENTION

Interventions	Stimulation
1. To shoulder	C V U
2. To breast	C V -
3. Held close	C - -
4. Infant seat up	- V U
5. Infant seat to side	- V -
6. Female voice	- - -

Stimulation: C = Contact

V = Vestibular

U = Upright



MEAN VISUAL ALERTNESS SCORES FOR 64 TWO DAY OLD NEONATES IN RESPONSE TO 6 STIMULUS CONFIGURATIONS